Peculiarities of the quasi-long-range ordered phase in a diluted two-dimensional XY model

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The results of a study of the XY model on a two-dimensional lattice with quenched nonmagnetic impurities will be reported. The research deals with such important effects of the dilution as the quantitative change in the spacial spin-spin correlations in the quasi-long-range ordered (QLRO) phase and the reduction of the critical temperature characterizing transition from the QLRO phase to a disordered phase. The interplay of structural and topological defects (vortices) essential for this model is studied with proper rigor by means of the Villain model.

The most essential results of the work are the following. The decay of the spin-spin correlation function is found to be of a power-law form with an exponent different from that of the pure model and dependent on the concentration of dilution. The interaction energy of non-magnetic impurities and topological defects as a function of their separation found within the Villain model approves the attractive character of the interaction and allows for the analytic estimation of the vortex-on-vacancy pinning energy. The mentioned expression for the interaction energy allows as well for the theoretical description of the critical temperature reduction basing on the Kosterlitz-Thouless vortex-antivortex pairs dissociation model.

Where possible, the presented analytical findings are compared to the Monte Carlo simulation results for the diluted two-dimensional XY systems performed by the authors or borrowed from the available literature sources exhibiting good agreement.